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**APPENDIX 2: CHARACTER LIST**

**CRANIAL OSTEOLOGY AND A NEW DIAGNOSIS OF THE LATE**

**PERMIAN PAREIASAUR NANOPARIA LUCKHOFFI (BROOM,**

**1936) FROM THE KAROO BASIN OF SOUTH AFRICA, AND**

**A CONSOLIDATED PAREIASAURIAN PHYLOGENY**

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List of characters used in the phylogenetic analysis.

We used the character list of Van den Brandt (*et al.,* 2022) and modified it by; re-wording characters 25, 32 and 44; by including the three new characters of Cisneros (*et al.,* 2021) (140-142); and by introducing an additional character state (state 2) for character 47, “Quadratojugal, anterior extend: reaches or almost reaches the anterior margin of the orbit (2)” for *Nanoparia*, *Pumiliopareia*, *Provelosaurus* and *Pareiasuchus peringueyi.*

At each character we cite the history of its use in previous analyses (author: character number), as published in Tsuji (2013: Appendix 1), for analyses published up until Turner (*et al.,* 2015). All analyses conducted thereafter (i.e. Xu *et al.,* 2015; Benton, 2016; Liu & Bever, 2018; Cisneros *et al.,* 2021; Van den Brandt *et al.,* 2020, 2022, 2023- this study) used the character list of Turner (*et al.,* 2015: 1-139 characters) and therefore these authors are not cited at each character, unless modifications were made (author: character number modified). Characters 140-142 were added by Cisneros (*et al.,* 2021).

**Braincase (characters 1-28, except 21, 22)**

1. Basicranial articulation: Pterygoid and/or epipterygoid articulation with the basipterygoid process is mobile (0); articulation is immobile (1). (Lee, 1997:2; deBraga & Rieppel, 1997:72; Jalil & Janvier, 2005:1; Tsuji, 2013:1; Turner *et al.,* 2015:1)
2. Sphenethmoid, ossification: absent (0); present (1). (Modified from Lee, 1995:10, Lee, 1997:3; deBraga & Rieppel, 1997 – see discussion about sphenethmoid vs. pleurosphenoid therein; Jalil & Janvier, 2005:2; Tsuji, 2013:2; Turner *et al.,* 2015:2)
3. Prootic, medial wall, ossification: absent (0): present (1). (Lee, 1993:A6, Lee, 1995:1, Lee, 1997:4; deBraga & Rieppel, 1997:68; Jalil & Janvier, 2005:3; Tsuji, 2013:3; Turner *et al.,* 2015:3)
4. Exoccipital, lateral flange: absent (0); present (1). (Lee, 1993:A4, Lee, 1995:2, Lee, 1997:5; Laurin & Reisz, 1995:64; Jalil & Janvier, 2005:4; Tsuji, 2013:4; Turner *et al.,* 2015:4)
5. Exoccipital, lateral flange, size: small flange (0); lateral flange of the exoccipital well-developed and extends well along the paroccipital process of the opisthotic (1). (Lee, 1993:A4, Lee, 1995:2, Lee 1997:5; Laurin & Reisz, 1995:64; Jalil & Janvier, 2005:4; Tsuji, 2013:4; Turner *et al.,* 2015:5)
6. Paroccipital process, suture: not sutured to the squamosal and supratemporal (0); paroccipital process of the opisthotic is antero-posteriorly expanded and sutured to ventrally-directed flange from the squamosal and supratemporal (1). (Modified from Lee, 1993:A3, Lee, 1995:4, Lee, 1997:6; deBraga & Rieppel, 1997:61&66; Jalil & Janvier, 2005:5; Tsuji, 2013:5; Turner *et al.,* 2015:6)
7. Paroccipital process, orientation: projects laterally from the neurocranium (0); is U-shaped in occipital view (1). (Lee, 1997:7; Jalil & Janvier, 2005:6; Tsuji, 2013:6; Turner *et al.,* 2015:7)
8. Ventral otic fissure: present (0); absent (1). (Lee, 1993:A5, Lee, 1995:5, Lee 1997:8; deBraga & Rieppel, 1997:63; Jalil & Janvier, 2005:7; Tsuji, 2013:7; Turner *et al.,* 2015:8)
9. Parabasisphenoid and basioccipital, braincase floor: not thickened (0); thickened (1). (Lee, 1995:6, Lee, 1997:9; Jalil & Janvier, 2005:8; Tsuji, 2013:8; Turner *et al.,* 2015:9)
10. Cultriform process: present (0); absent (1). (Lee, 1993:C2, Lee, 1995:7, Lee, 1997:10; Jalil & Janvier, 2005:9; Tsuji, 2013:9; Turner *et al.,* 2015:10)
11. Cultriform process, length: relatively long, more than the half of the distance between the anterior extent of the rostrum (tip of snout) to the basal tubera (0); short, less than a third of this distance (1). (Lee, 1993:C2, Lee, 1995:7, Lee, 1997:10; Jalil & Janvier, 2005:9; Tsuji, 2013:9; Turner *et al.,* 2015:11)
12. Cultriform process, shape of anterior tip: pointed (0); blunt (1). (Lee, 1995:8, Lee, 1997:11; Jalil & Janvier, 2005:10; Tsuji, 2013:10; Turner *et al.,* 2015:12)
13. Basisphenoid, body: wide, strongly constricted, giving it an hourglass shape in ventral view (0); wide, not strongly laterally constricted (1); narrow with relatively straight margin (2). (Lee, 1997:12; deBraga & Rieppel, 1997:64; Jalil & Janvier, 2005:11; Tsuji, 2013:11; Turner *et al.,* 2015:13; Liu & Bever, 2018:13 modified)
14. Basisphenoid, ventral surface of each basipterygoid process, turbercles: featureless, lacking tubercles (0); tubercles present on the ventral surface of each basipterygoid process (basisphenoid), immediately posterior to the interpterygoid vacuity and the transverse suture with the pterygoid (1). (Lee, 1997:13; Jalil & Janvier, 2005:12; Tsuji, 2013:12; Turner *et al.,* 2015:14; Van den Brandt *et al.,* 2022:14 modified)
15. Basioccipital, ventral surface, central boss: absent (0); present (1). (Jalil & Janvier, 2005:13; Tsuji, 2013:13; Turner *et al.,* 2015:15)
16. Basal tubera: absent (0); present (1). (Lee, 1995:9, Lee, 1997:14; Jalil & Janvier, 2005:14; Tsuji, 2013:14; Turner *et al.,* 2015:16)
17. Basal tubera, position: situated posteriorly, closer to the occipital condyle than the basipterygoid process (0); basal tubercles situated approximately midway between the occipital condyle and the basipterygoid processes, or even further anteriorly (1). (Lee, 1997:15; Jalil & Janvier, 2005:15; Tsuji, 2013:15; Turner *et al.,* 2015:17)
18. Choana, shape: situated in a lateral position, bounded laterally by the maxilla, diverge posteriorly, parallel to tooth row throughout (0); parallel, positioned more medially, delimited posterolaterally by the palatine (1); choanae even more medially positioned, with the palatine constituting more than 50% of the lateral border, medial border formed entirely by the vomer (2). (Modifed from Lee, 1993:A1, Lee, 1995:11, Lee, 1997:16; Laurin & Reisz, 1995:40; deBraga & Rieppel, 1997:8; Jalil & Janvier, 2005:16; Tsuji, 2013:16; Turner *et al.,* 2015:18)
19. Vomer, alar flange (lateral flange): absent (0); present (1). (Modified from Damiani & Modesto, 2001; Jalil & Janvier, 2005:17; Tsuji, 2013:17; Turner *et al.,* 2015:19)
20. Foramen palatinum posterius, size: small or absent and delineated by the bones of the skull roof (0); large, medially positioned and defined by the palatine and the ectopterygoid without participation of the bones of the skull roof (1). (Modified from Lee, 1993:A2, Lee, 1995:12, Lee, 1997:17; Laurin & Reisz, 1995:41; deBraga & Reisz, 1996:74; Jalil & Janvier, 2005:18; Tsuji, 2013:18; Turner *et al.,* 2015:20)
21. Skull roof, radiating ridges: dermal sculpturing in the form of relatively straight ridges radiating from the center of dermal skull roof bones absent (0); regular ridges present (1). (Tsuji, 2013:115; Turner *et al.,* 2015:21)
22. Circular pits: cranial sculpture in the form of circular pits absent (0); present (1). (Tsuji, 2013:116; Turner *et al.,* 2015:22)
23. Medial prepalatal foramen bordered by the premaxilla and the vomer: absent (0); present (1). (Jalil & Janvier, 2005:19; Tsuji, 2013:19; Turner *et al.,* 2015:23)
24. Interpterygoid vacuity, length: long, at least 15% of skull length (0) short, less than 15% of skull length (1). (Laurin & Reisz, 1995:39; Tsuji, 2013:20; Turner *et al.,* 2015:24)
25. Interpterygoid vacuity, anterior shape: V-shaped, extends far anteriorly and is anteriorly pointed (0); anterior border is upside-down U-shaped, anteriorly bulged (pointing) or convex (1); transversely-oriented, anterior border is U-shaped or posteriorly bulged or convex (2).(Lee, 1997:18; deBraga & Rieppel, 1997:73; Jalil & Janvier, 2005:20; Tsuji, 2013:21; Turner *et al.,* 2015:25; Van den Brandt *et al.,* 2023:25 modified)
26. Pterygoid, transverse flange, shape: large and directed laterally (0); reduced, directed more anteriorly than laterally, without contact with the cheek (1). (Modified from Lee, 1993:A7, Lee, 1995:13, Lee, 1997:19; deBraga & Rieppel, 1997:80; Jalil & Janvier, 2005:21; Tsuji, 2013:22; Turner *et al.,* 2015:26)
27. Pterygoid, transverse flange, orientation: extends ventrally below the level of the alveolar ridge (0); oriented primarily horizontally, so the level of the palate is higher, not reaching the level of the alveolar ridge (1). (Lee, 1993:A9, Lee, 1995:14, Lee, 1997:20; Jalil & Janvier, 2005:22; Tsuji, 2013:23; Turner *et al.,* 2015:27)
28. Supraoccipital, form: large, with longitudinal contact with the postparietal (0); high and narrow, forming along all of its length a solid sagittal suture with a ventral projection of the postparietal (1). (Modified from Lee, 1993:A8, Lee, 1995:3, Lee, 1997:21; Jalil & Janvier, 2005:23; Tsuji, 2013:24; Turner *et al.,* 2015:28)

**Skull Roof (characters 29-58, and 21, 22)**

1. External naris, form: round and small (0); very anteroposteriorly elongate (1). (Lee, 1995:16, Lee, 1997:23; Jalil & Janvier, 2005:25; Tsuji, 2013:25; Turner *et al.,* 2015:29)
2. External naris, maxilla contribution: maxilla either excluded from naris or forms only its ventral/posterior edge (0); maxilla extends also to the posterodorsal margin of naris (1). (Müller & Tsuji, 2007:137; Tsuji, 2013:125; Turner *et al.,* 2015:30)
3. Maxilla, boss: a boss or horn on the maxilla immediately posterior to the external naris feebly developed or absent (0); prominent boss or horn present (1). (Lee, 1997:25; deBraga & Rieppel, 1997:12; Jalil & Janvier, 2005:27; Tsuji, 2013:26; Turner *et al.,* 2015:31, Van den Brandt *et al.,* 2022:31 modified)
4. Maxilla, dorsal process: reduced, not reaching the nasal, so that the lacrimal contributes to the ventral border of the naris (0); large anterodorsal extension of the maxilla, excluding the lacrimal from the external naris (1). (Modified from Laurin & Reisz, 1995:19; Lee, 1997:26; deBraga & Rieppel, 1997:17; Jalil & Janvier, 2005:28; Tsuji, 2013:27; Turner *et al.,* 2015:32; Van den Brandt *et al.,* 2023:32 modified)
5. Snout dimensions (anteriorly): broader than high (0); as high as wide (1). (Lee, 1997:30; Jalil & Janvier, 2005:31; Tsuji, 2013:28; Turner *et al.,* 2015:33)
6. Postfrontal, shape: mediolaterally narrow, more than 2 times as long as wide, contributes to the orbital margin (0); widened mediolaterally, around 2 times as wide as long, no or only feeble contribution to the orbital rim (1). (Modified from Lee, 1995:25, Lee, 1997:31; Jalil & Janvier, 2005:32; Tsuji, 2013:29; Turner *et al.,* 2015:34 modified)
7. Postfrontal, ‘horn’: absent (0); present (1). (Tsuji *et al.,* 2013:126; Turner *et al.,* 2015:35)
8. Orbit, shape: circular, no posterior emargination (0); posterior emargination of orbits (1). (Lee, 1995:23, Lee, 1997:32; Jalil & Janvier, 2005:33; Tsuji, 2013:30; Turner *et al.,* 2015:36)
9. Circumorbital tuberocities: circumorbital skull elements lacking tubercles or bosses (0); circumorbital tubercles small (1); circumorbital tubercles large (2). (Modified from Tsuji, 2006:45; Tsuji, 2013:114; Turner *et al.,* 2015:37, Liu & Bever, 2018:37 modified)
10. Pineal foramen, position: pineal foramen situated about halfway along the interparietal suture (0); placed more anteriorly, close to the frontal-parietal suture (1). (Modified, combined two characters from Lee; Lee, 1995:17, Lee, 1997:33, Lee, 1993:C2, Lee, 1995:18, Lee, 1997:34; Laurin & Reisz, 1995:3; Jalil & Janvier, 2005:34 & 35; Tsuji, 2013:31; Turner *et al.,* 2015:38)
11. Tabular (supernumerary element): present (0); absent (1). (Modified from Lee, 1997:36; Jalil & Janvier, 2005:37; Tsuji, 2013:32; Turner *et al.,* 2015:39)
12. Tabular (supernumerary element), form: small, largely an occipital element (0); integrated into skull table (1). (Modified from Lee, 1997:36; Jalil & Janvier, 2005:37; Tsuji, 2013:32; Turner *et al.,* 2015:40)
13. Tabular (supernumerary element), contact: do not contact each other posteriorly (0); very well-developed, make contact posteriorly, excluding the postparietals from the posterior edge of the skull table (1). (Modified from Jalil & Janvier, 2005:38; Tsuji, 2013:33; Turner *et al.,* 2015:41)
14. Postparietal, form: small, largely an occipital element (0); integrated into skull table (1). (Modified from Lee, 1995:20, Lee, 1997:37; Jalil & Janvier, 2005:39; Tsuji, 2013:34; Turner *et al.,* 2015:42)
15. Postparietal, fusion: paired (0); fused into a single element and exposed well dorsally (1). (Modified from Laurin & Reisz, 1995:4 & 5; Lee, 1997:38; deBraga & Rieppel, 1997:52; Jalil & Janvier, 2005:40; Tsuji, 2013:35; Turner *et al.,* 2015:43)
16. Expanded quadratojugal (cheek) flange: absent, no cheek flange, quadratojugal (cheek) does not extend below level of tooth row, the ventral surface of the quadratojugal is continuous with and forms a straight edge with that of the maxilla (0); small cheek flange present, quadratojugal (cheek) flange extends below the level of the maxillary tooth row 0° – 40° (1); large cheek flange present, quadratojugal (cheek) flange extends below the level of the maxillary tooth row 41° or more (2). (Lee, 1997:45; Jalil & Janvier, 2005:46; Tsuji, 2013:38; Turner *et al.,* 2015:44; Liu & Bever, 2018:44; Van den Brandt *et al.,* 2020, 2023:44 modified)
17. Jugal, anterior process: does not extend to anterior orbital rim (0); extends at least to level of orbital rim (1). (Laurin & Reisz, 1995:11; Tsuji, 2013:117; Turner *et al.,* 2015:45)
18. Jugal, suture with maxilla: straight, jugal thins out smoothly towards anterior, or upright, but no dramatic vertical 'step' (0); “stepped”, anteriormost tip of jugal very narrow but expands broadly posteriorly along with a dramatic thinning of the posterior process of the maxilla (1). (Modified from Müller & Tsuji, 2007:133; Tsuji, 2013:123; Turner *et al.,* 2015:46)
19. Quadratojugal, anterior extent: does not reach level of posterior border of orbit (0); reaches posterior border of orbit (1); reaches or almost reaches the anterior margin of the orbit (2). (Modified from Laurin & Reisz, 1995: 23; Tsuji, 2013:118; Turner *et al.,* 2015:47; Van den Brandt *et al.,* 2023:47 modified)
20. Quadratojugal, ventral margin, ornamentation (bosses): absent, no ornamentation (bosses) on the ventral margin of the quadratojugal (0); present, ornamentation (bosses) on the ventral margin of the quadratojugal (1). (Lee, 1997:47; Jalil & Janvier, 2005:48; Tsuji, 2013:40; Turner *et al.,* 2015:48; Van den Brandt *et al.,* 2020:48 modified)
21. Junction of skull table and cheek: both flat surfaces, form a distinct angle where they meet, particularly posterior to the orbits (0); postorbital portion of this junction is rounded, no clear edge between these two surfaces posterior to the orbit (1). (Lee, 1997:41; Jalil & Janvier, 2005:43; Tsuji, 2013:36; Turner *et al.,* 2015:49, Van den Brandt *et al.,* 2022:49 modified)
22. Cheek ornamentation style (quadratojugal and squamosal): no ornamentation on the posterior or ventral margins of the cheek (0); ornamentation present on the posterior or ventral margins of the cheek in the form of low rounded bosses (1); ornamentation present on the posterior or ventral margins of the cheek in the form of well-developed, more distinct, taller, more pointed bosses (2); ornamentation present on the posterior or ventral margins of the cheek in the form of prominent, conical horns with sharp, pointed tips (3). (Modified from Lee, 1995:27, Lee, 1997:46; deBraga & Rieppel, 1997:43; Jalil & Janvier, 2005:47; Tsuji, 2013:39; Turner *et al.,* 2015:50, Van den Brandt *et al.,* 2020:50 modified)
23. Temporal emargination (otic notch): absent, or very small (0), emargination present on the posterior border of the cheek, in the dorsal portion of the squamosal, just below the occipital shelf of the supratemporal, being horizontal and extending medially along the internal surface of the squamosal (1). (Lee, 1995:29, Lee, 1997:43; Jalil & Janvier, 2005:45; Tsuji, 2013:37; Turner *et al.,* 2015:51, Liu & Bever, 2018:51; Van den Brandt *et al.,* 2020:51 modified)
24. Temporal, otic notch, position: restricted to posterior half of cheek (0); closely approaches the orbital margin (1). (Müller & Tsuji, 2007:135; Tsuji, 2013:124; Turner *et al.,* 2015:52)
25. Temporal, ventral emargination: absent (0); present (1). (Modified from Laurin & Reisz, 1995:30; Tsuji, 2013:41; Turner *et al.,* 2015:53)
26. Postorbital region of skull, length: length at least equals anteroposterior extension of orbit (0); postorbital region shorter than anteroposterior extension of orbit (1). (Modified from Laurin & Reisz, 1995:32; Tsuji, 2013:42; Turner *et al.,* 2015:54)
27. Frontal, contribution to the orbit: present (0); frontals excluded from the orbit by contact between the prefrontal and postfrontal (1). (Laurin & Reisz, 1995:2; modified from Lee, 1997:48; deBraga & Rieppel, 1997:22; Jalil & Janvier, 2005:49; Tsuji, 2013:43; Turner *et al.,* 2015:55)
28. Frontal, shape: slim and long, four times as long as wide (0); frontals short, with a length not more than two times the width (1). (Lee, 1995:24, Lee, 1997:49; deBraga & Rieppel, 1997:26; Jalil & Janvier, 2005:50; Tsuji, 2013:44; Turner *et al.,* 2015:56)
29. Frontal, central boss: absent (0); present (1). (Tsuji *et al.,* 2013:127; Turner *et al.,* 2015:57)
30. Boss ornamentation: dermal bosses of skull bones have no central pointed horn (0); dermal bosses of cranial bones have a central long, pointed horn (1). (Jalil & Janvier, 2005:51; Tsuji, 2013:45; Turner *et al.,* 2015:58)

**Lower jaw (characters 59-64)**

1. Jaw articulation, position: anterior to occiput (0); even with occiput (1). (Laurin & Reisz, 1995:36; Tsuji, 2013:120; Turner *et al.,* 2015:59)
2. Mandibular symphysis: splenial is excluded from the mandibular symphysis (0); splenial forms the ventral portion of the mandibular symphysis (1). (Lee, 1997:51; Jalil & Janvier, 2005:52; Tsuji, 2013:46; Turner *et al.,* 2015:60)
3. Angular, boss: absent, ventral surface of the angular is smooth (0); boss is present (1). (Lee, 1997:52; Jalil & Janvier, 2005:53; Tsuji, 2013:47; Turner *et al.,* 2015:61)
4. Angular, boss, form: low and rounded (0, prev. 1); well developed with a prominent, pointed tubercle (1, prev. 2). (Lee, 1997:52; Jalil & Janvier, 2005:53; Tsuji, 2013:47; Turner *et al.,* 2015:62)
5. Articular, retroarticular process, dorsal projection: without a projection, tapers gradually to end (0); small projection (“dorsal lump” of Lee, 1997) present at the very posterior end of the retroarticular process (1). (Lee, 1997:54; Jalil & Janvier, 2005:55; Tsuji, 2013:48; Turner *et al.,* 2015:63)
6. Articular (region), lateral shelf: absent, the lateral surface of the articular region is smooth (0); present, there is a lateral extension of the surangular or articular, the lateral surface of the effected element extends dorsolaterally (1). (Laurin & Reisz, 1995:78; – Modified slightly from Jalil & Janvier, 2005:56; Tsuji, 2013:49; Turner *et al.,* 2015:64)

**Dentition (characters 65-73)**

1. Teeth, labiolingual compression (anteroposteriorly expanded): teeth not labio-lingually compressed (0); teeth labio- lingually compressed, leaf-shaped, with small denticles on the tooth crown (1); labio- lingual compression very pronounced, giving the marginal teeth a fan shape (2). (Modified from Lee, 1997:58; Jalil & Janvier, 2005:60; Tsuji, 2013:52; Turner *et al.,* 2015:65)
2. Teeth, cusp arrangement: three central cusps close together, more lateral cusps farther apart and spaced farther apart from each other than these central three (0); cusps regularly spaced along the tooth crown (1). (Lee, 1997:61; Jalil & Janvier, 2005:61; Tsuji, 2013:53; Turner *et al.,* 2015:66)
3. Maxillary teeth, orientation: maxillary teeth oriented vertically, teeth point directly downwards (0); alveolar ridge inflected towards the palate, teeth oriented ventromedially (1). (Lee, 1997:27; Jalil & Janvier, 2005:57; Tsuji, 2013:50; Turner *et al.,* 2015:67)
4. Upper jaw teeth (premaxilla and maxilla), number on each side: 20 or more (0), 18 or less (1). (Xu *et al.,* 2015:51; Turner *et al.,* 2015:68; Van den Brandt *et al.,* 2020:68 modified)
5. Maxillary teeth, cusp number: conical, single cusp (0); 7–9 cusps on each maxillary tooth (1); 9–11 cusps (2); more than 11 cusps (3). (Lee, 1997:59; Jalil & Janvier, 2005:62; Tsuji, 2013:54; Turner *et al.,* 2015:69; Van den Brandt *et al.,* 2022:69 modified)
6. Mandibular teeth, cusp number: conical, without cusps (0); 2–7 cusps on each mandibular tooth (1); 7–9 cusps (2); 9–11 cusps (3); more than 11 cusps (4). (Modified from Lee, 1997:60; Jalil & Janvier, 2005:63; Tsuji, 2013:55; Turner *et al.,* 2015:70)
7. Mandibular teeth, lingual surface, shape: smooth (0); has a distinct, triangular lingual ridge, narrowing towards the crown of the tooth (1). (Lee, 1997:63; Jalil & Janvier, 2005:64; Tsuji, 2013:56; Turner *et al.,* 2015:71)
8. Marginal teeth, lingual surface, horizontal cingulum: absent (0); present (1). (Xu *et al.,* 2015:57; Turner *et al.,* 2015:72)
9. Marginal teeth, lingual surface, cingulum, extent: on some maxillary teeth (0); on most maxillary teeth (1). (Xu *et al.,* 2015:57; Turner *et al.,* 2015:73)

**Palate (characters 74-78)**

1. Pterygoid, transverse flange, dentition: no dentition on the transverse flange of the pterygoid (0); teeth present on the transverse flange of the pterygoid (1). (Lee, 1997:65; Jalil & Janvier, 2005:66; Tsuji, 2013:58; Turner *et al.,* 2015:74; Van den Brandt *et al.,* 2022:74 modified)
2. Pterygoid, anterior extent: reaches level of choana (0); posterior to choana (1). (Laurin & Reisz, 1995:44; Tsuji, 2013:113; Turner *et al.,* 2015:75)
3. Pterygoid, quadrate ramus: merges smoothly into transverse flange without distinctive excavation (0); deep excavation on posterolateral surface (1). (deBraga & Reisz, 1996:33; Tsuji, 2013:122; Turner *et al.,* 2015:76)
4. Palatal teeth: medial rows of palatal denticles parallel and close together and to the medial axis of the skull (0); medial rows of palatal denticles widely separated, converging anteriorly (1). (Modified from Lee, 1997:66; Jalil & Janvier, 2005:67; Tsuji, 2013:59; Turner *et al.,* 2015:77)
5. Caniniform region: present (0); absent (1). (Laurin & Reisz, 1995:24; Tsuji, 2013:119; Turner *et al.,* 2015:78)

**Vertebrae (characters 79-86)**

1. Atlas-axis fusion: pleurocentrum of the atlas and axial intercentrum fused (0); atlas pleurocentrum separate from the axial intercentrum (1). (Laurin & Reisz, 1995:85; Jalil & Janvier, 2005:69; Tsuji, 2013:61; Turner *et al.,* 2015:79; Cisneros *et al.,* 2021: 79 polarity reversed)
2. Presacral vertebrae, number: more than 20 presacral vertebrae (0); 20 presacral vertebrae (1); 19 or fewer presacral vertebrae (2). (Modified from Lee, 1993:B1, Lee, 1995:35, Lee, 1997:67; Laurin & Reisz, 1995:81; deBraga & Rieppel, 1997:97; Jalil & Janvier, 2005:68; Tsuji, 2013:60; Turner *et al.,* 2015:80)
3. Lumbar vertebrae: absent (0); present (1). (Lee, 1995:36, Lee, 1997:68; Jalil & Janvier, 2005:70; Tsuji, 2013:62; Turner *et al.,* 2015:81)
4. Sacral vertebrae, number: two (0); three (1); four (2); five (3). (Lee, 1997:93; Jalil & Janvier, 2005:71; Tsuji, 2013:63; Turner *et al.,* 2015:82)
5. Caudal vertebrae, number (tail length): long, with more than 25 caudal vertebrae (0); short, less than 25 caudal vertebrae (1). (Lee, 1997:70; Jalil & Janvier, 2005:73; Tsuji, 2013:64; Turner *et al.,* 2015:83)
6. Caudal vertebrae, lateral projections: generally present on the first five but never on more than 9 of the first (most anterior) caudal vertebrae (0); prominent lateral projections on at least the first 9 caudal vertebrae (1). (Modified from Lee, 1993:A10, Lee, 1995:37, Lee 1997:71; Laurin & Reisz, 1995:90; deBraga & Rieppel, 1997:110; Jalil & Janvier, 2005:74; Tsuji, 2013:65; Turner *et al.,* 2015:84)
7. Caudal vertebrae, lateral projections, shape: projections form an 'L', as their distal portions are recurved posteriorly parallel to the axis of the body (0); projections almost straight and directed laterally (1). (Lee, 1997:72; deBraga & Rieppel, 1997:111; Jalil & Janvier, 2005:75; Tsuji, 2013:66; Turner *et al.,* 2015:85)
8. Caudal vertebrae, hemal arch, insertion: between two caudal vertebrae (0); articulate with only one centrum via a facet of articulation found on posteroventral projections of the centra (1). (Lee, 1993:A11, Lee, 1995:39, Lee, 1997:73; Laurin & Reisz, 1995:91; deBraga & Rieppel, 1997:112; Jalil & Janvier, 2005:76; Tsuji, 2013:67; Turner *et al.,* 2015:86)

**Scapulocoracoid (characters 87-91)**

1. Scapula, blade, length: less than two times the glenoid fossa diameter (0), between two and three times the glenoid fossa diameter (1), greater than or equal to three times the glenoid fossa diameter (2). (Lee, 1993:B2, Lee, 1995:41, Lee, 1997:75; Laurin & Reisz, 1995:96; Jalil & Janvier, 2005:78; Tsuji, 2013:69; Turner *et al.,* 2015:87)
2. Scapula, blade, shape: straight preaxial and postaxial margins expanding gradually (0); preaxial and postaxial margins are curved, expansion pronounced dorsally at the distal end (flared) (1). (Turner *et al.,* 2015:88)
3. Acromion process: absent (0), present (1). (Lee, 1993:A12, Lee, 1995:40, Lee, 1997:74; Laurin & Reisz, 1995:91; deBraga & Rieppel, 1997:112; Jalil & Janvier, 2005:77; Tsuji, 2013:68; Turner *et al.,* 2015:89)
4. Posterior coracoid, dorsal edge: almost horizontal, meets the posterior border of the scapula at an angle of less than 135° (0); dorsal edge of the posterior coracoid is oriented posteroventrally, forms an angle of more than 135° with the posterior border of the scapula (1). (Lee, 1997:77; Jalil & Janvier, 2005:80; Tsuji, 2013:70; Turner *et al.,* 2015:90)
5. Cleithrum: present (0); absent (1). (Laurin & Reisz, 1995:94; deBraga & Rieppel, 1997:113; Lee, 1997:79; Jalil & Janvier, 2005:81; Tsuji, 2013:71; Turner *et al.,* 2015:91)

**Humerus (characters 92-104)**

1. Humerus, torsion: the planes of proximal and distal expansion makes an angle of greater than or equal to 60° (0), less than or equal to 45° (1), less than or equal to 20° (2). (Lee, 1997:81; deBraga & Rieppel, 1997:123; Jalil & Janvier, 2005:83; Tsuji, 2013:72; Turner *et al.,* 2015:92)
2. Ectepicondyle, form: narrow and rounded (0); preaxially expanded wide rectangular flange (1). (Lee, 1997:82; Jalil & Janvier, 2005:84; Tsuji, 2013:73; Turner *et al.,* 2015:93)
3. Ectepicondylar foramen: absent (0); present (1). (Modified from Lee, 1993:A13, Lee, 1995:43, Lee, 1997:83; Laurin & Reisz, 1995:102; deBraga & Rieppel, 1997:127; Jalil & Janvier, 2005:85; Tsuji, 2013:74; Turner *et al.,* 2015:94)
4. Entepicondyle, form: postaxially expanded wide rectangular flange (0); narrow and rounded (1). (Lee, 1997:84; Jalil & Janvier, 2005:86; Tsuji, 2013:75; Turner *et al.,* 2015:95)
5. Entepicondylar foramen, form: completely enclosed (0); an 'open groove' (1). (Lee, 1995:44, Lee, 1997:85; Jalil & Janvier, 2005:87; Tsuji, 2013:76; Turner *et al.,* 2015:96)
6. Entepicondylar foramen, location: exposed in distal dorsal (extensor) view (0); ventral (flexor) view (1). (Lee, 1997:86; Jalil & Janvier, 2005:88; Tsuji, 2013:77; Turner *et al.,* 2015:97).
7. Epicondylar distal projection: epicondyles do not project (far) past the radial and ulnar articulation surfaces (0); project past the radial and ulnar articulation surfaces, appearing ‘forked’ (1). (Lee, 1997:87; Jalil & Janvier, 2005:89; Tsuji, 2013:78; Turner *et al.,* 2015:98)
8. Entepicondyle and ectepicondyle relative size: equal (0); ectepicondyle reduced (1). (Turner *et al.,* 2015:99)
9. Radial condyle of the humerus, location: entirely ventral (0); more terminally, encroaches onto the distal end of the humerus (1). (Lee, 1997:90; Jalil & Janvier, 2005:92; Tsuji, 2013:81; Turner *et al.,* 2015:100)
10. Humerus, ulnar articulation surface, form: groove bordered posteriorly by a faint ridge (0); groove bordered posteriorly by a prominent tubercle (1). (Lee, 1997:89; Jalil & Janvier, 2005:91; Tsuji, 2013:80; Turner *et al.,* 2015:101)
11. Humerus, intercondylar depression, transverse ridge (intercondylar ridge border): on the distal dorsal end of the humerus, a transverse ridge separating the ulnar fossa (intercondylar depression) from the articulation (olecranon fossa) surface is absent (0); present (1). (Lee, 1997:88; Jalil & Janvier, 2005:90; Tsuji, 2013:79; Turner *et al.,* 2015:102; Van den Brandt *et al.,* 2022:102 modified)
12. Humerus, ulnar fossa (intercondylar depression), depth: shallow depression (0); deep fossa (1). (Turner *et al.,* 2015:103)
13. Humerus, ulnar fossa (intercondylar depression), width: ulnar fossa is much wider than the olecranon process (0); ulnar fossa is ‘narrow’, same width as olecranon process (1). (Turner *et al.,* 2015:104)

**Ulna (characters 105, 106)**

1. Ulna, olecranon process, articulation surface: oriented medially (0); oriented terminally (1). (Lee, 1997:91; Jalil & Janvier, 2005:93; Tsuji, 2013:82; Turner *et al.,* 2015:105)
2. Ulna, olecranon process, size: well developed, greatly expanded past the most preaxial surface of the proximal articulation surface (0); reduced, nearly level with preaxial surface of the proximal articulation surface (1). (Lee, 1997:91; Jalil & Janvier, 2005:93; Tsuji, 2013:82; Turner *et al.,* 2015:106)

**Manus (character 107)**

1. Manus, phalangeal formula: 23452, not reduced (0); 23332 reduced (1). (Lee, 1993:B5, Lee, 1995:45, Lee, 1997:92; Laurin & Reisz, 1995:106; Jalil & Janvier, 2005:94; Tsuji, 2013:83; Turner *et al.,* 2015:107)

**Sacral ribs (character 108)**

1. Sacral ribs, second and third: dorsoventral compression is slight (0); strong and sheet-like (1). (Lee, 1997:94; Jalil & Janvier, 2005:95; Tsuji, 2013:84; Turner *et al.,* 2015:108)

**Pelvis (characters 109-119)**

1. Ilium, crista sacralis: weakly developed (0); well developed (1). (Lee, 1997:95; Jalil & Janvier, 2005:96; Tsuji, 2013:85; Turner *et al.,* 2015:109)
2. Ilium, blade, expansion: not or only slightly anteriorly (0); well anteriorly (1). (Lee, 1997:97; Jalil & Janvier, 2005:98; Tsuji, 2013:87; Turner *et al.,* 2015:110)
3. Ilium, anterior margin, lateral eversion: flat or slightly everted (0); surface strongly everted, oriented almost horizontal (1). (Lee, 1997:98; Jalil & Janvier, 2005:99; Tsuji, 2013:88; Turner *et al.,* 2015:111)
4. Ilium, posterior process: long (0); strongly reduced (1). (Lee, 1995:48, Lee, 1997:99; Jalil & Janvier, 2005:100; Tsuji, 2013:89; Turner *et al.,* 2015:112)
5. Ilium, shaft, orientation: vertical or posterodorsally inclined (0); anterodorsally inclined, forming an angle with the vertical of more than 20° (1); inclined even further anteriorly, forming an angle of more than 45° with the vertical (2). (Lee, 1997:96; Jalil & Janvier, 2005:97; Tsuji, 2013:86; Turner *et al.,* 2015:113)
6. Acetabulum, dorsal buttress: not well developed (0); strongly developed (1). (Lee, 1993:A16, Lee, 1995:47, Lee, 1997:100; Laurin & Reisz, 1995:109; Jalil & Janvier, 2005:101; Tsuji, 2013:90; Turner et *al.,* 2015:114)
7. Acetabulum, anterior shape: round (0), notched (1). (Lee, 1997:101; Jalil & Janvier, 2005:102; Tsuji, 2013:91; Turner *et al.,* 2015:115)
8. Pubis, process on the anterior border: absent (0); present (1). ('lateral pubic process' of Walker, 1973, Gaffney, 1990). (Lee, 1997:104; Jalil & Janvier, 2005:105; Tsuji, 2013:93; Turner *et al.,* 2015:116)
9. Pubis, median process: absent (0); present (1). (Lee, 1997:105; Jalil & Janvier, 2005:106; Tsuji, 2013:94; Turner *et al.,* 2015:117)
10. Pelvic symphysis, length: long (0), short (1). (Lee, 1997:103; Jalil & Janvier, 2005:104; Tsuji, 2013:92; Turner *et al.,* 2015:118)
11. Pelvic symphysis, dorsoventral thickness: thin (0), thick (1). (Lee, 1997:103; Jalil & Janvier, 2005:104; Tsuji, 2013:92; Turner *et al.,* 2015:119)

**Femur (characters 120-125)**

1. Femur, head, preaxial expansion: no curvature (0); slight (1); strong (2). (Lee, 1997:107; Jalil & Janvier, 2005:107; Tsuji, 2013:95; Turner *et al.,* 2015:120)
2. Femur, trochanter major: absent (0); present (1). (Lee, 1993:A14, Lee, 1995:50, Lee, 1997:109; Jalil & Janvier, 2005:109; Tsuji, 2013:96; Turner *et al.,* 2015:121)
3. Femur, trochanter major, form: small, slightly thickened (0); large, more distinct (1). (Lee, 1993:A14, Lee, 1995:50, Lee, 1997:109; Jalil & Janvier, 2005:109; Tsuji, 2013:96; Turner *et al.,* 2015:122)
4. Femur, postaxial flange, length: limited to proximal region (0); extends entire length of femur (1). (Lee, 1997:112; Jalil & Janvier, 2005:112; Tsuji, 2013:97; Turner *et al.,* 2015:123)
5. Femur, postaxial flange, width: narrows in the middle of the length of the femur (0); consistently wide, appearing straight (1). (Lee, 1997:112; Jalil & Janvier, 2005:112; Tsuji, 2013:97; Turner *et al.,* 2015:124)
6. Femur, internal trochanter, shape: in ventral view, appears straight (0); proximally curved preaxially (1). (Lee, 1997:114; Jalil & Janvier, 2005:114; Tsuji, 2013:98; Turner *et al.,* 2015:125)

**Tibia (character 126)**

1. Cnemial crest: cnemial crest of the tibia (longitudinal ridge on the dorsal (lateral or external) surface of the tibia) well developed and prominent (0); ridge and accompanying groove much reduced (1). (Lee, 1997:115; Jalil & Janvier, 2005:115; Tsuji, 2013:99; Turner *et al.,* 2015:126)

**Tarsus (character 127)**

1. Astragalus and calcaneum: separate or sutured (0); fused, with the presence of the obturator foramen (1). (Modified from Lee, 1993:B6, Lee, 1995:51, Lee, 1997:116; Laurin & Reisz, 1995:117; deBraga & Rieppel, 1997:149; Jalil & Janvier, 2005:116; Tsuji, 2013:100; Turner *et al.,* 2015:127)

**Pes (characters 128-131)**

1. Pes, phalangeal formula: 23454 or 23453 (0); 23343 (1). (Lee, 1993:B7, Lee, 1995:53, Lee, 1997:118; Laurin & Reisz, 1995:122; deBraga & Rieppel, 1997:161; Jalil & Janvier, 2005:118; Tsuji, 2013:101; Turner *et al.,* 2015:128)
2. Pes, fifth digit: large, always longer than the first pedal digit (0); reduced, slender, shorter than the first pedal digit (1). (Lee, 1993:A15, Lee ,1995:54, Lee, 1997:119; Laurin & Riesz, 1995:120; deBraga & Rieppel, 1997:159; Jalil & Janvier, 2005:119; Tsuji, 2013:102; Turner *et al.,* 2015:129)
3. Pes, metapodial (metacarpal and metatarsal), shape: slender, close to two times as long as wide (0); robust, approximately as wide as long (1). (Lee, 1997:120; Jalil & Janvier, 2005:120; Tsuji, 2013:103; Turner *et al.,* 2015:130)
4. Pes, non-terminal phalanges, shape: slender, 50% longer than wide (0); short, as long as wide (1); even shorter and more massive, about two times as wide as long (2). (Lee, 1995:46, Lee, 1997:121; Jalil & Janvier, 2005:121; Tsuji, 2013:104; Turner *et al.,* 2015:131)

**Osteoderms (characters 132-138)**

1. Osteoderms, body coverage: Osteoderms absent on the body (0); present (1). (Lee, 1997:122; deBraga & Rieppel, 1997:165; Jalil & Janvier, 2005:122; Tsuji, 2013:105; Turner *et al.,* 2015:132)
2. Osteoderms, body coverage, extent: osteoderms form only a longitudinal band closely overlying the vertebral column (0); cover entire dorsal surface of the body including flanks (1). (Lee, 1997:122; deBraga & Rieppel, 1997:165; Jalil & Janvier, 2005:122; Tsuji, 2013:105; Turner *et al.,* 2015:133)
3. Osteoderms, appendages: no osteoderms over the appendages (0); fore and hind limbs covered with numerous conical osteoderms (1). (Lee, 1997:127; deBraga & Rieppel, 1997:167; Jalil & Janvier, 2005:127; Tsuji, 2013:110; Turner *et al.,* 2015:134)
4. Osteoderm, appearance: dorsal surface of the osteoderms smooth, convex, without a central boss (0); possess a distinct rounded central boss (1); central boss on osteoderm capped by a small conical spine (2). (Lee, 1997:123; Jalil & Janvier, 2005:123; Tsuji, 2013:106; Turner *et al.,* 2015:135)
5. Osteoderm, ornamentation: external surface of the osteoderms smooth and without ornamentation (0); osteoderms ornamented with fine, straight, regularly spaced ridges radiating out from a central boss to the edge (1); ridges fewer, larger, lumpier, and less regularly spaced (2). (Lee, 1997:124; deBraga & Rieppel, 1997:166; Jalil & Janvier, 2005:124; Tsuji, 2013:107; Turner *et al.,* 2015:136)
6. Osteoderm, dimension: round and small, with a dimension no larger than diameter of the centra of the dorsal vertebrae (0); osteoderms large, with a maximal length the same as or larger than the dorsal vertebral centra (1). (Lee, 1997:125; Jalil & Janvier, 2005:125; Tsuji, 2013:108; Turner *et al.,* 2015:137)
7. Osteoderm, position: osteoderms do not touch, separated by a space (0); osteoderms more densely packed, often touching one another, but touching only on the shoulder and pelvic regions, never sutured or articulated over the trunk (1); osteoderms overlapping, articulated or sutured, forming a continuous layer on the dorsal surface of the body (2). (Modified from Lee, 1997:126; Jalil & Janvier, 2005:126; Tsuji, 2013:109; Turner *et al.,* 2015:138)

**Gastralia (character 139)**

1. Gastralia: present (0); absent (1). (Lee, 1995:56, Lee, 1997:128; deBraga & Rieppel, 1997:168; Jalil & Janvier, 2005:128; Tsuji, 2013:111; Turner *et al.,* 2015:139)

**Extra (character 140-142)**

1. Marginal teeth, at mid region of maxilla or jaw, dorsoventrally tall (root-apical/mesiodistal ratio = 1.5 or higher), present (0), or absent (1). (Cisneros *et al.,* 2021:140; Van den Brandt *et al.,* 2023:140)
2. Premaxillary tooth number, three (0), four or more (1), or two (2). (Cisneros *et al.,* 2021:141; Van den Brandt *et al.,* 2023:141)
3. If the tabular (=supernumerary bone) is dorsally expanded, it does not contact the parietal (0), or it contacts the parietal (1). (Cisneros *et al.,* 2021:142; Van den Brandt *et al.,* 2023:142)

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